Quantum Information with Solid-State Devices

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Dr. Johannes Majer

Lecture 8

ATOMINSTITUT

TU WIEN

RF-SQUID

Quantum superposition of distinct macroscopic states

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external flux Φ_x applied to the loop. The dynamics of the SQUID can be described in terms of the variable Φ and are analogous to those of a particle of 'mass' C (and kinetic energy $\frac{1}{2}C\dot{\Phi}^2$) moving in a one-dimensional potential (Fig. 1a) given by the sum of the magnetic energy of the loop and the Josephson coupling energy of the junction:
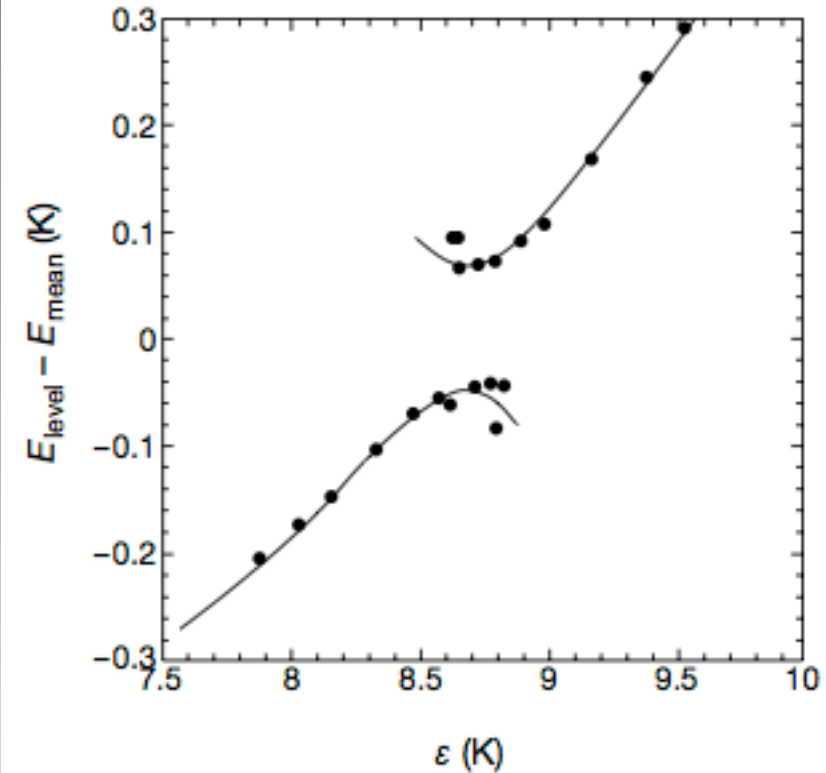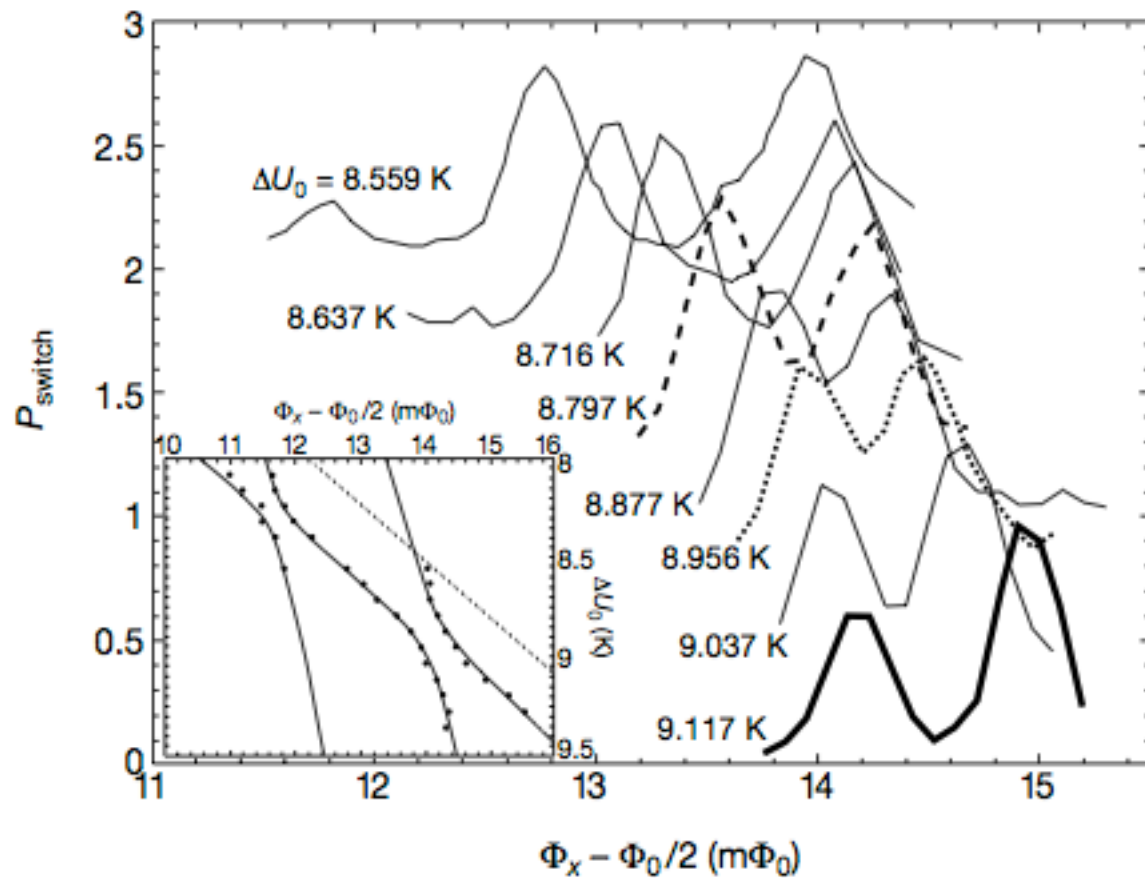
$$U = U_0\left[\frac{1}{2}\left(\frac{2\pi(\Phi - \Phi_x)}{\Phi_0}\right)^2 - \beta_L\cos(2\pi\Phi/\Phi_0)\right] \quad (1)$$

where Φ_0 is the flux quantum, $U_0 \equiv \Phi_0^2/4\pi^2 L$ and $\beta_L \equiv 2\pi L I_c/\Phi_0$. For the parameters used in our experiment, this a double-well potential separated by a barrier with a height depending on I_c. When $\Phi_x = \Phi_0/2$ the potential is symmetric. Any change in Φ_x then tilts the potential, as shown in Fig. 1a.
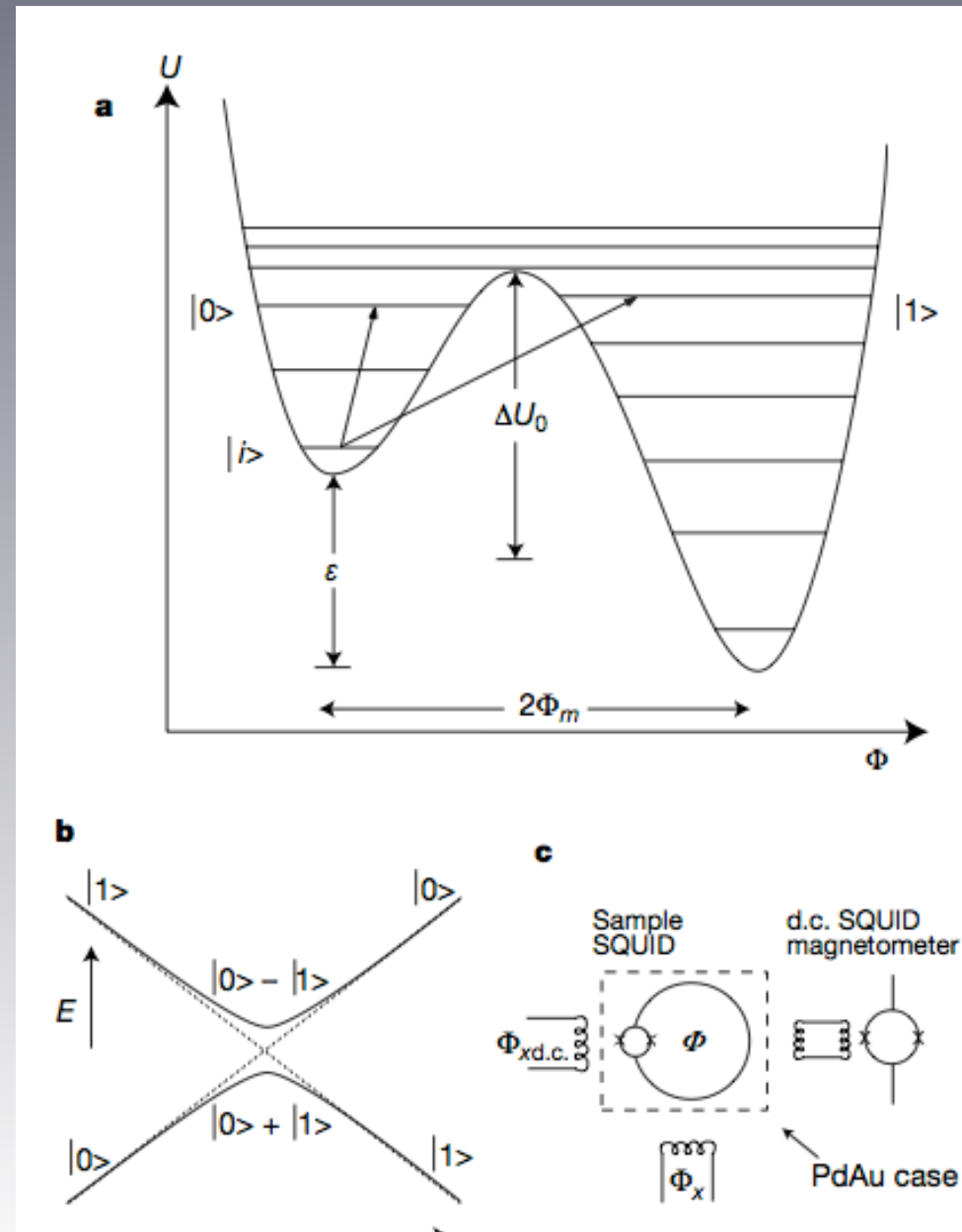
RF-SQUID

Phase Qubit
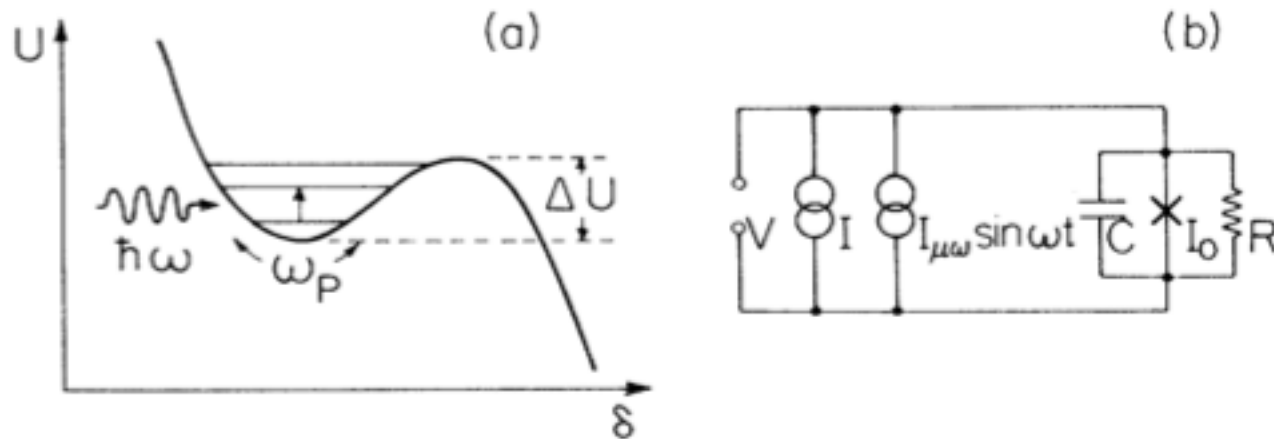
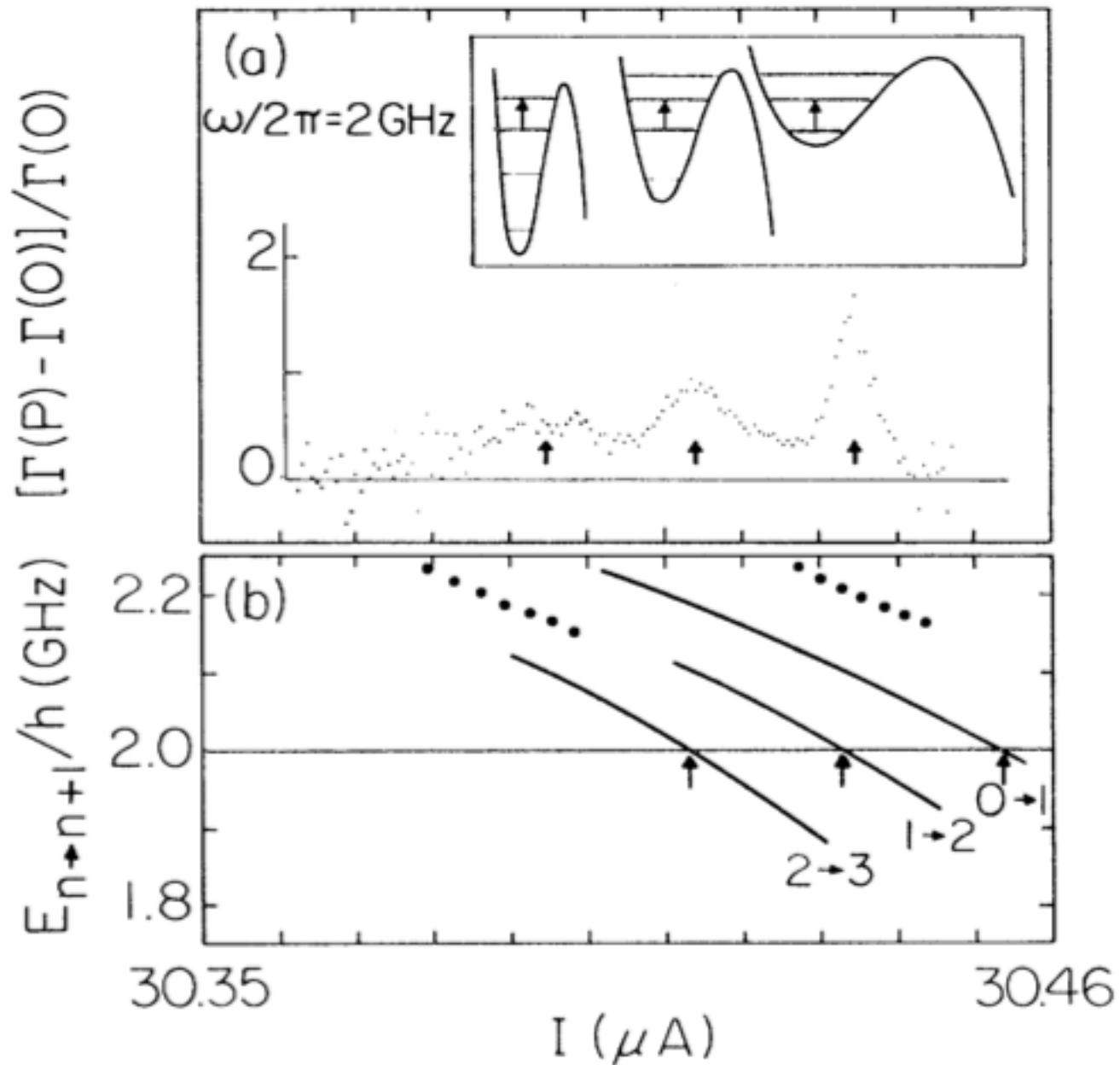### Energy-Level Quantization in the Zero-Voltage State of a Current-Biased Josephson Junction

John M. Martinis, Michel H. Devoret,[a] and John Clarke

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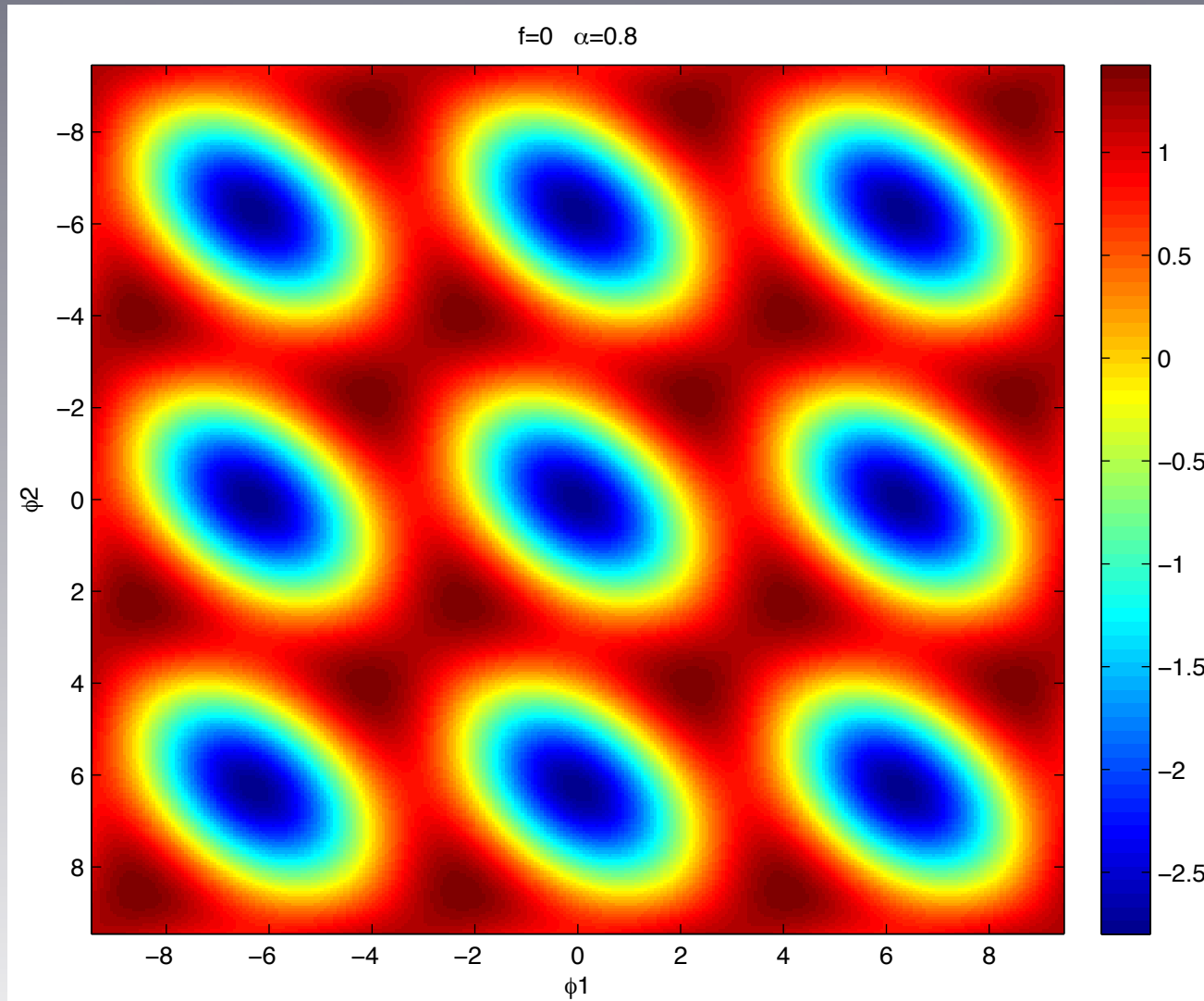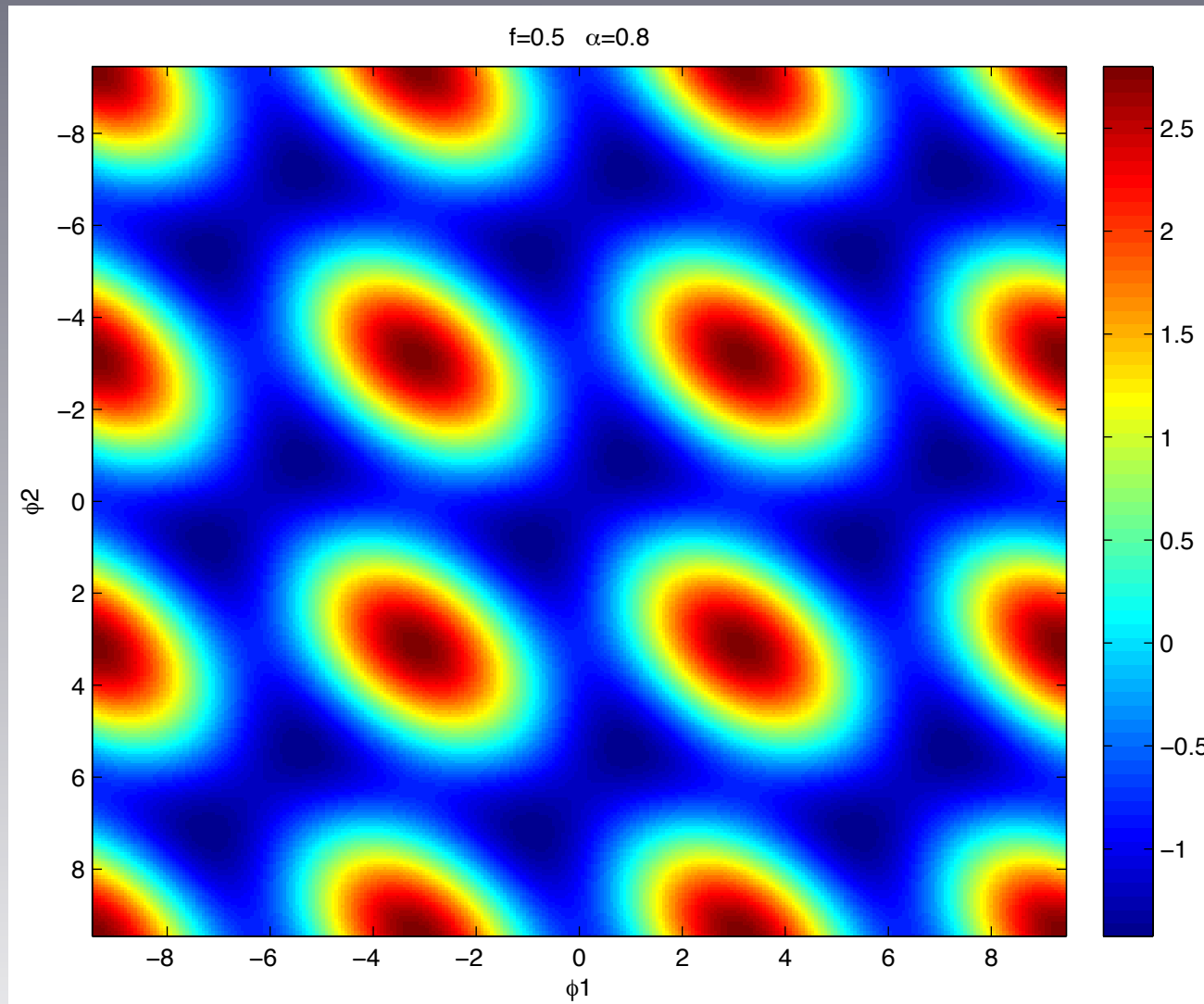
Phase Qubit

persistent-current qubit

f=0

persistent-current qubit
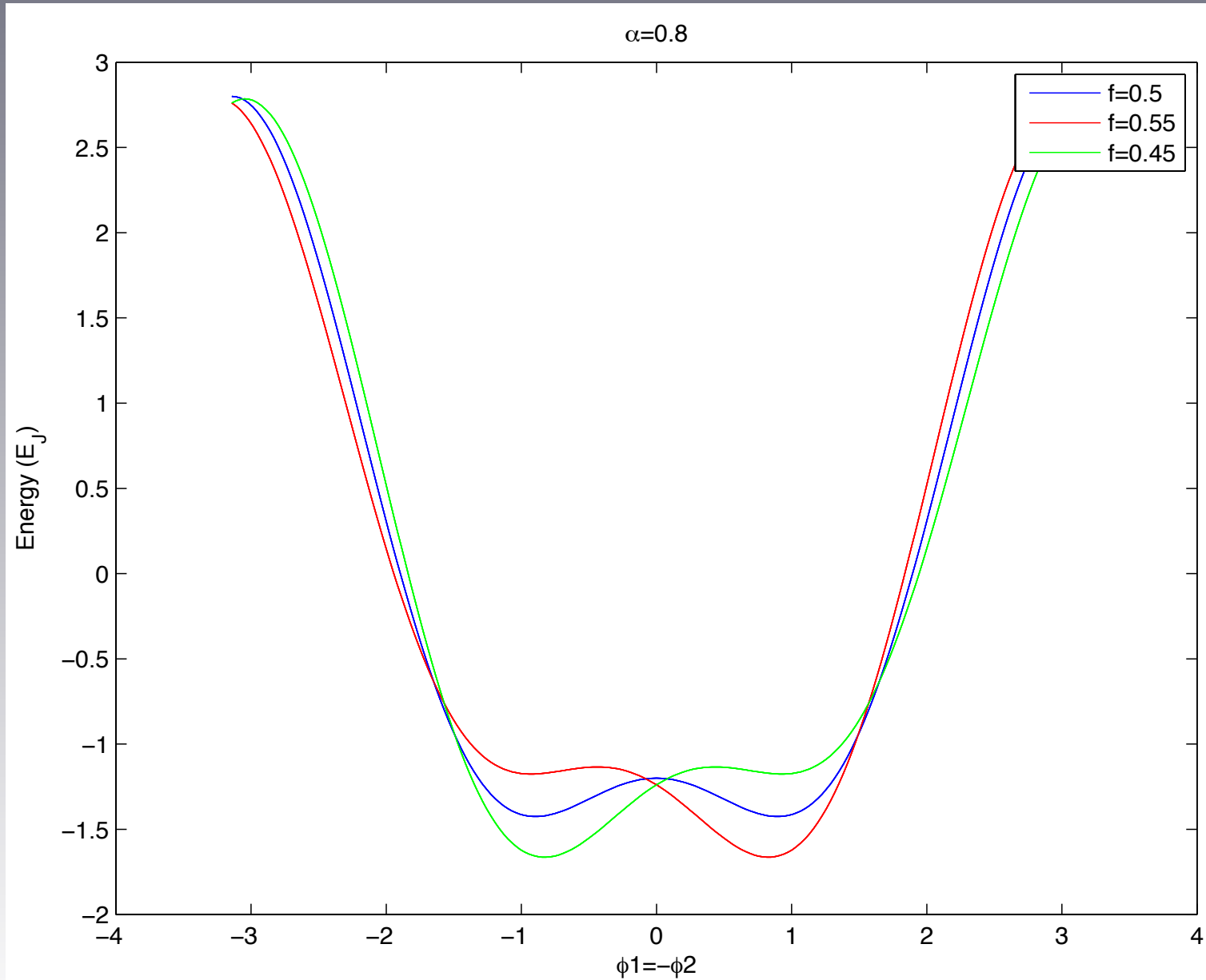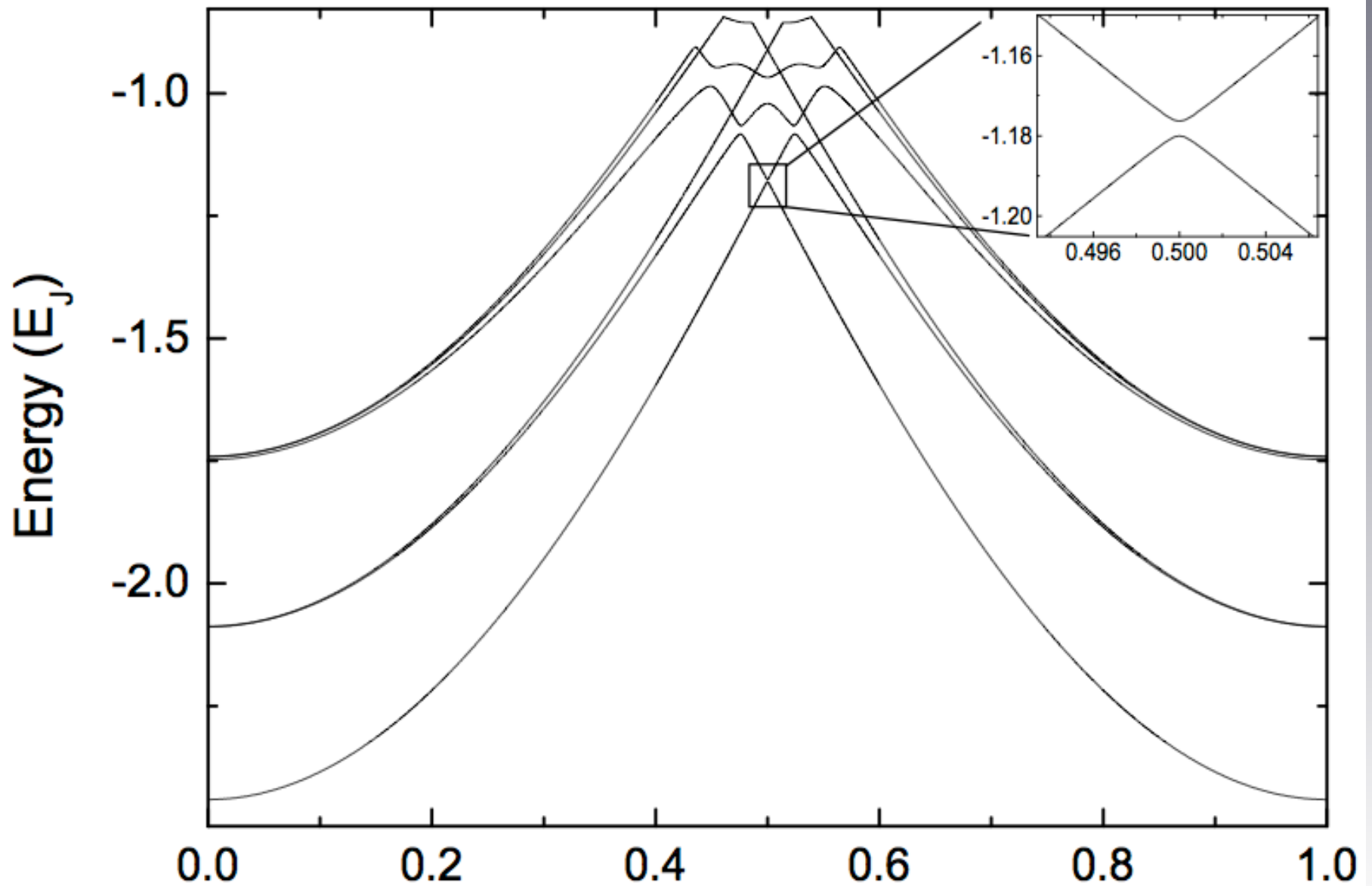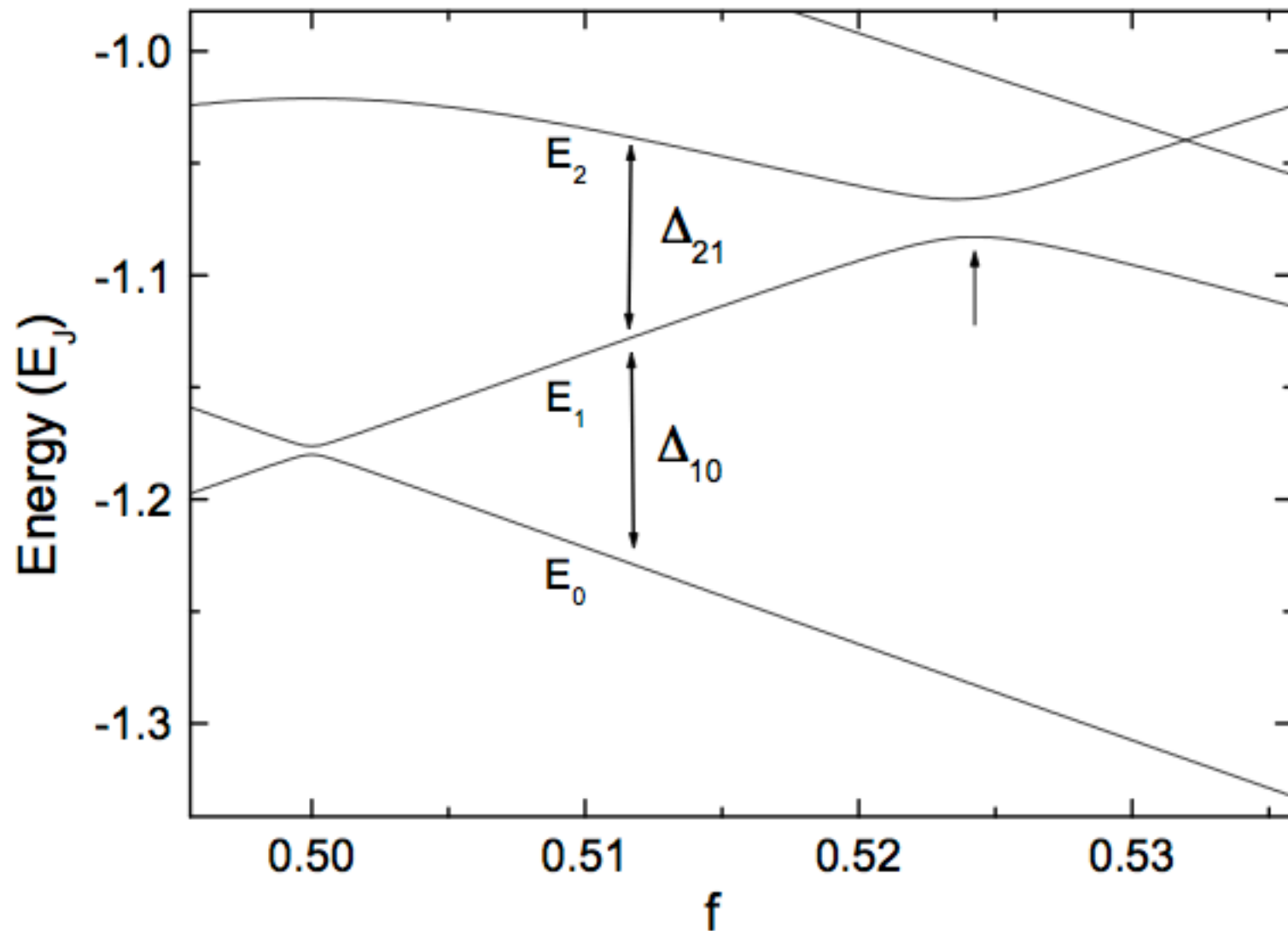

f=0.5   α=0.8
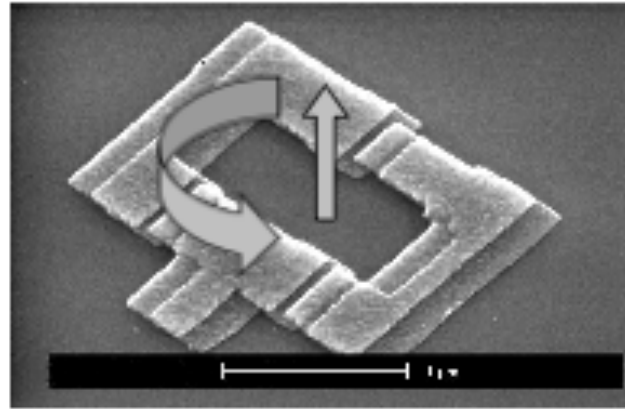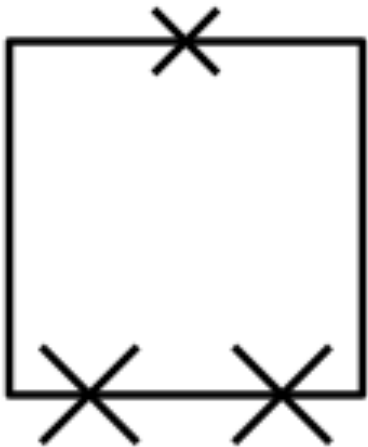
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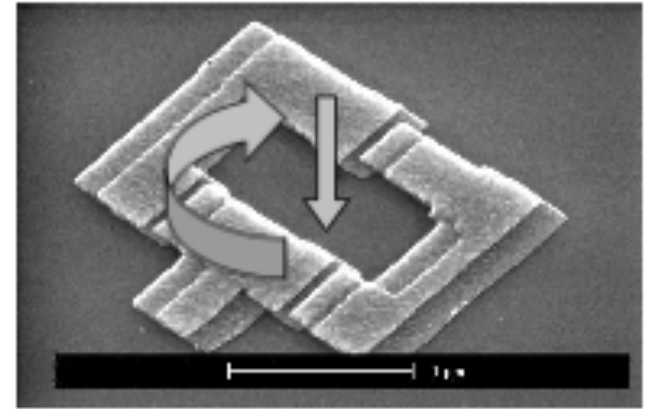
persistent-current qubit

persistent-current qubit

persistent-current qubit
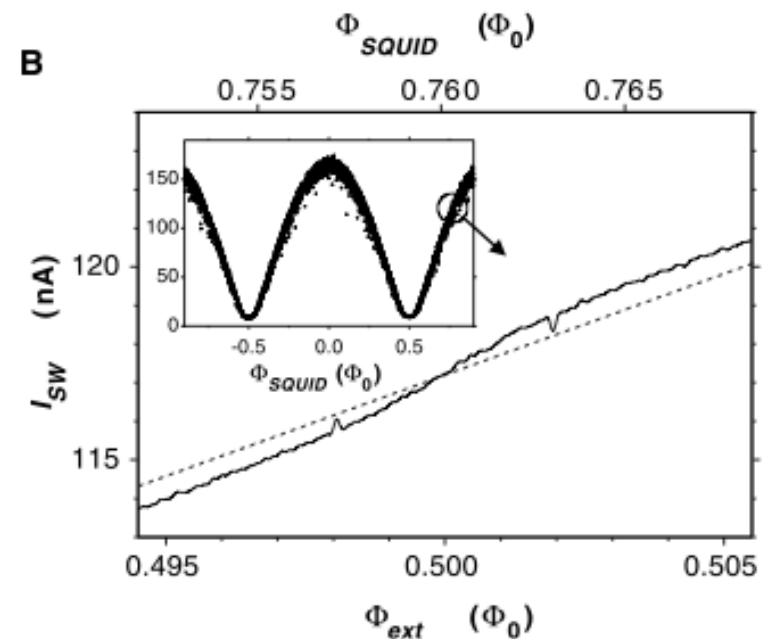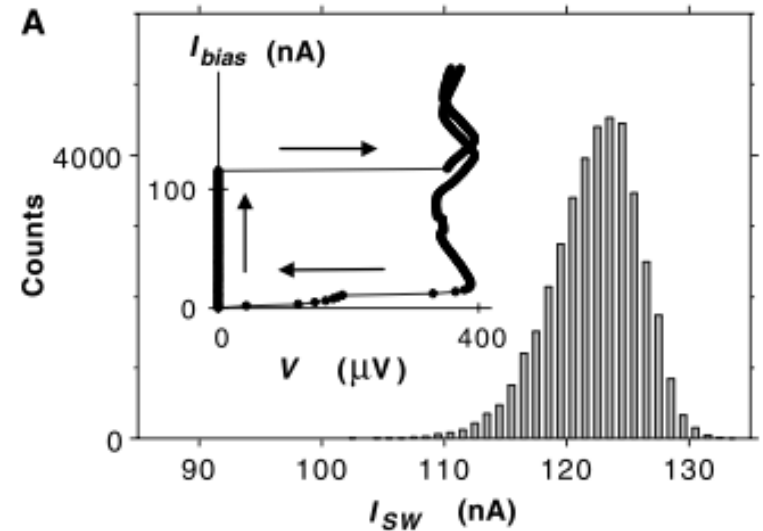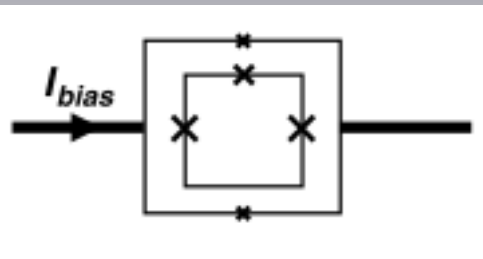
persistent-current qubit

spin up   spin down

persistent-current qubit

Quantum Superposition of Macroscopic Persistent-Current States

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persistent-current qubit